USDA Forest Service
Research Paper RM-72
June 1971

simulating yields of managed dwarf mistletoe-infested lodgepole pine stands

by Clifford A. Myers, Frank G. Hawksworth
and James L. Stewart

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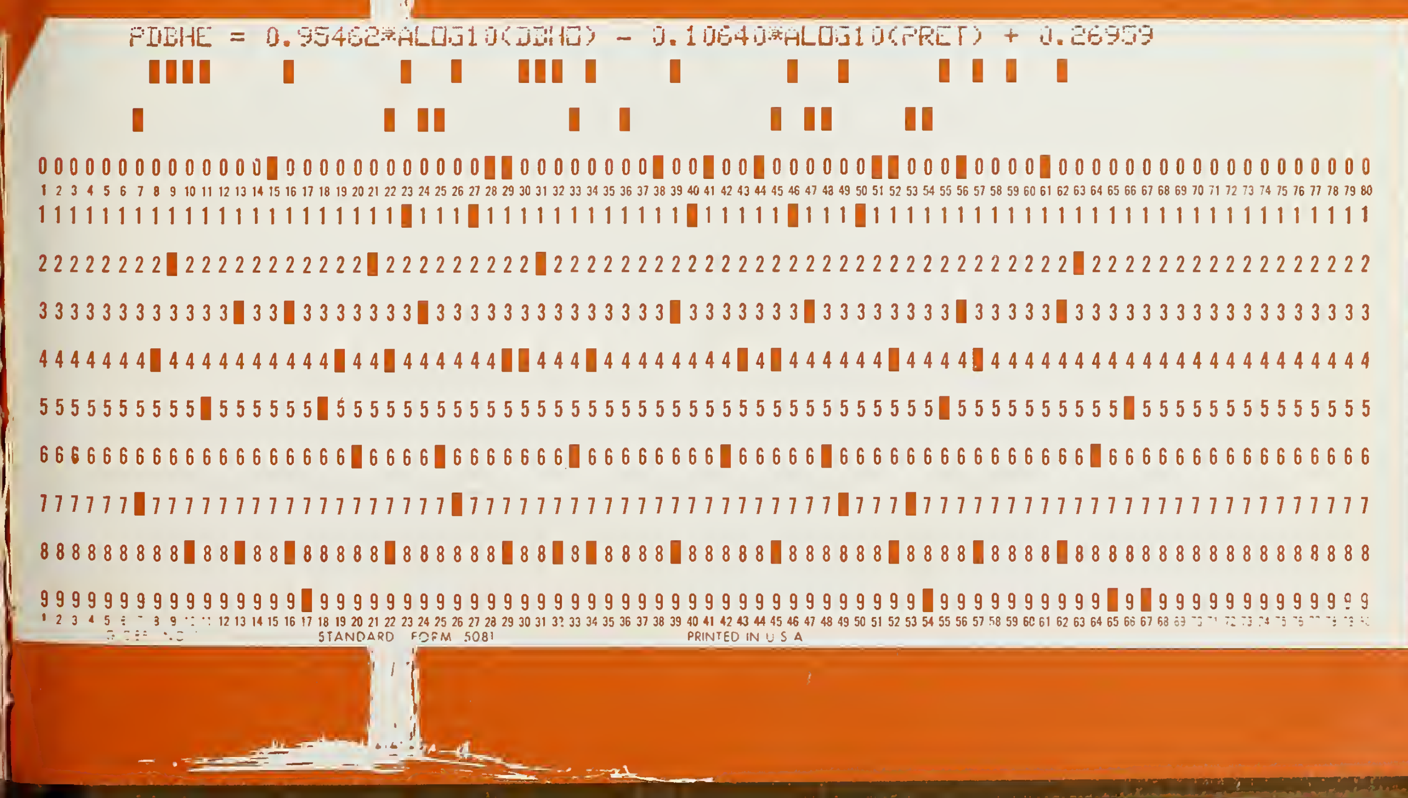
U.S. Department of Agriculture
Forest Service



ABSTRACT

Presents a procedure for computation of yield tables for diseased, managed, even-aged stands of lodgepole pine in Colorado and southern Wyoming. Stand age at time of initial infection by dwarf mistletoe may be varied as desired. Other control variables include stand age at initial thinning, stocking goals, and frequency of thinning. Stand conditions and severity of dwarf mistletoe infestation change with time and in response to intermediate cuttings.

Key Words: Stand yield tables, timber management, forest management, simulation, *Arceuthobium americanum*, *Pinus contorta*.

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Simulating Yields of Managed, Dwarf Mistletoe-Infested Lodgepole Pine Stands

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CONTENTS

Simulating Yields of Managed, Dwarf Mistletoe-Infested Lodgepole Pine Stands

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and James L. Stewart

Introduction

Procedures are available for predicting yields in healthy, managed stands of lodgepole pine (Pinus contorta Dougl.) in the central Rocky Mountains (Myers 1967). More than half the lodgepole pine stands in this area, however, are infested with dwarf mistletoe, Arceuthobium americanum Nutt. ex Engelm. (Hawksworth 1958). Management decisions must be made for each of these stands. Possible alternatives are: (1) sanitation thinning, (2) no treatment with the hope that the stands may eventually become merchantable, or (3) destruction and regeneration. Information on potential yields is needed to help forest managers evaluate these alternatives. Procedures and a computer program for predicting yields in dwarf mistletoe-infested stands are presented here to meet this need. A subsequent publication will discuss details of application for pathologists and forest managers.

Information is available on the effects of A. americanum on growth rates of individual lodgepole pine trees. Weir (1916) compared dominant heavily infected and healthy lodgepole pines in Washington and Idaho. His data, based on 50 infected trees 65 years old and 50 healthy trees 60 years old in the same stands, are summarized below. Initially, trees that became infected were growing faster in diameter than those that remained healthy.

	Height (Feet)	D.b.h. (Inches)	Radial growth, last 40 years (Inches)
Healthy	48.5	7.8	2.93
Infected	35.2	6.3	.93
Infected, as percent of healthy	73	81	32

Baranyay and Safranyik (1970) studied the effects of dwarf mistletoe on the growth of lodgepole pines in Alberta, Canada. Volume differences were significant only between heavily infected and healthy trees, and the amount of loss increased with age of infection. Mortality was significantly greater in stands on dry sites than on moist sites.

Hawksworth and Hinds (1964) demonstrated the effects of dwarf mistletoe in stands less than 150 years old. The amount of damage caused by the parasite was most closely related to time since initial infection, but also, to a lesser extent, to stand age when initial infection occurred. Reduction in total height and d.b.h. growth of dominant and codominant trees averaged about 0.7 percent per year since time of infection. In heavily infested stands, growth losses and increased mortality reduced cubic-foot volume by 1 to 2 percent per year. Their study dealt with past effects of the parasite in unmanaged stands; it did not provide data that could be used for direct yield prediction in managed stands.

Data Collection

Methods used were similar to those outlined by Myers (1966, 1967) for healthy stands, but with additional information on the extent of dwarf mistletoe infection in each tree.

Seventy-nine temporary plots were established in even-aged lodgepole pine stands in Colorado and southern Wyoming. Stands varied in site index from 30 to 85, and dwarf mistletoe infestation ranged from none to very heavy.

The plots conformed to the following standards:

1. Were uniform in site quality, range of tree sizes, and stand density on and adjacent to the plot.
2. Varied in area with average stand diameter. Most plots contained approximately 150 trees, and ranged from 0.020 to 0.345 acre.

3. Supported even-aged, thinned or unthinned stands that had not been cut or otherwise disturbed within 13 years prior to measurement. The 3 years beyond the 10-year measurement period was to allow for severe adjustments in form that would not be expected in continually managed stands.
4. Had stand diameters reasonably close to those possible in managed stands of equal age. Some leeway was found to be allowable in this standard, but all extreme conditions were rejected.

The extent of infection in each tree was ranked on the 42 plots with dwarf mistletoe by a 6-class mistletoe rating system (Hawksworth 1961). The live crown was divided horizontally into thirds. Each third was rated as:

0 = No mistletoe.
1 = Light — less than half the branches infected.
2 = Heavy — more than half the branches infected.

The ratings for each third of the crown were added to obtain the total for the tree. The rating for a tree can therefore vary from 0 (no infection) to 6 (heavy infection in all thirds).

Measurements made on each plot are indicated by entries on the sample field forms (figs. 1 and 2). Only values needed to carry out necessary computations are shown. Additional information can be obtained, if desired, especially if local experience indicates that additional independent variables should be tested in the regression analyses.

The plot description form (fig. 1) provided spaces for recording descriptive material and the results of computations. Results that need appear only on computer printouts are given to provide a complete list.

Field measurements of living trees were those shown in columns two to seven of figure 2. Each tree was given a temporary number by stapling a numbered card to it. This permitted most efficient use of small crews. The record of figure 2 was completed one column at a time, yet all data from any one tree could still be identified as such. Diameters of all trees on each plot were measured with a diameter tape. Total heights of all trees were measured with either a marked pole placed beside the tree, a Suunto hypsometer, or an Abney level. The record of heights provided data for: (1) site index determination (6-8 trees), (2) construction of a height-diameter curve, and (3) determining average height of dominant and codominant trees (about 20). Total ages were determined from borings of dominant and codominant trees at the ground line. Ages were determined for intermediate and overtopped trees when needed to confirm that the stand was even-aged, but were not used in computations. Radial growth of the wood at breast height was determined for each tree by boring along the best estimate of average radius.

Diameters (outside bark) of trees that died during the previous 10 years were recorded. Appearance of trees dead 0 to 10 years was determined by examination of dead trees on permanent plots and in stands for which date of thinning was known.

Information Needed

Field data described in the previous section were converted to volumes and other values for each plot and per acre. Basal area and other per-acre values, average stand diameter, and site index were then used as dependent and independent variables to obtain the prediction equations used in program LPMIST (appendix 1). The equations, shown as FORTRAN statements in the program listing, contain only significant independent variables.

Items computed and uses made of them in LPMIST were as follows:

1. Present diameter outside bark was converted to past diameter outside bark by use of radial wood growth and equations that account for bark growth (Myers 1964a).
2. Past number of trees equaled present number of live trees (fig. 2) plus any mortality during the previous 10 years. Past and present numbers were raised to an acre basis. Equations to estimate mortality in healthy (OUT) and diseased (DIE) stands were computed from density, mortality, and other data.
3. Present age of the main stand was the average of the ages of dominant and codominant trees (column 5 of fig. 2). Past age equaled present age minus 10 years.
4. Average height of dominant and codominant trees was obtained from columns 3 and 4 of figure 2. Prediction equations for height (HTSO) were determined from healthy stands with densities within the range of possible management goals. Data from infected plots were used to derive the equation for reduction in height growth due to disease (PCT).
5. Site index was calculated by methods outlined by Alexander (1966). Because heavy dwarf mistletoe infection reduces height growth, site index on heavily infested plots was estimated by measuring nearby healthy stands on comparable sites.

Lodgepole Pine Dwarf Mistletoe Yield Study
Plot Description and Summations

Plot No. 38 By FH + JD

Date 7/17/68

Location Colorado State Forest - 1 mile North of Michigan Lake

Plot area 0.06474 acres Blow-up factor 15.446

****

CCF 233 Dom. height 62 ft. Dom. age 106 yr.

Trial site index ______ Correction ______ Site index 70 ft.

Thinned NO Stocking level 10 years ago 220 +

STAND SUMMARY, PER ACRE

Item	Present	Past
Number of trees (live)	973	1128
Basal area, total	163.97	151.81
Average d.b.h., inches	5.22	4.62
Average height, feet	56	
Main stand age, years	106	96
Total cubic feet	4072.1	
Merchantable cubic feet	2469.9	
Board feet, Scribner	0.0	
Dwarf mistletoe rating	2.9	

Figure 1.--Sample field form for plot description and summary.

Lodgepole Pine Dwarf Mistletoe Yield Table Study
Description of Live Trees

Plot No. 38 Sheet 1 of 3 Sheets

(1) Tree No.	(2) Present D.B.H.	(3) Present Ht.	(4) Present Crown	(5) Present Age	(6) Present DMR	(7) 10-yr. radial growth	(8) P.I. Diam.	(9) Past D.B.H.
1	6.5	43	I		2	0.15	.3	6.2
2	7.1	52	C	104	3	0.15	.3	6.8
3	5.7	51	I		1	0.10	.2	5.5
4	6.1	48	I		3	0.10	.2	5.9
5	6.1	52	C		2	0.15	.3	5.8
6	2.6	30	S		4	0.05	.1	2.5
7	4.0	38	S		3	0.05	.1	3.9
8	4.1	42	S		2	0.10	.2	3.9
9	7.1	54	D		4	0.30	.6	6.5
10	9.5	52	D	109	4	0.20	.4	9.1
11	8.6	52	C		4	0.30	.6	8.0
12	1.3	12	S		6	0.00	.0	1.3
13	3.8	34	S		5	0.05	.1	3.7
14	4.4	47	I		4	0.10	.2	4.2
15	3.8	45	I		2	0.10	.2	3.6

Figure 2.--Sample field form for record of live trees.

6. Present basal area was computed with the diameters of column 2 of figure 2. Past basal area was obtained from the diameters of column 9 of figure 2 and diameters of the dead trees. Basal areas were later used in predictions of d.b.h., volume, and other variables.
7. Average stand diameter was the diameter of the tree of average basal area. This definition of average diameter was applied every place this variable was used or recorded as a result. Initial average diameters and other variables from healthy stands were used to obtain the equation for average d.b.h. after 10 years (DBHO). Data from diseased stands provided the equation for reduction in diameter growth due to dwarf mistletoe (TEM).
8. Cubic-foot and board-foot volumes on each plot were computed with tree volume equations of the form $V = a + b D^2 H$ (Myers 1964b, 1969). Plot volumes were raised to volumes per acre before use in other computations. Total cubic volumes were used to compute equations for stand volume in cubic feet (TOTO and TOTT). Total volumes plus merchantable cubic- and board-foot volumes were used to obtain equations for the volume conversion factors (FCTR and PROD) computed by subroutine LPVOL.
9. Present dwarf mistletoe rating of each plot was determined by averaging the individual ratings for all live trees on each plot. Estimates of periodic increases in dwarf mistletoe rating (DMR) of the plot trees were obtained from results of a previous study (Hawksworth and Hinds 1964).

Several prediction equations are used to obtain dwarf mistletoe ratings in LPMIST. One equation for DMR predicts the initial rating if the stand has never been thinned. Other equations for DMR predict the current rating as an increase from a past value. An expected post-thinning rating (DMRT) is computed if infection index is not so high (3.0 or greater) as to make thinning impractical and if a thinning from above has not already been made. An equation in subroutine LPCUT2 then predicts the percentage of trees to be removed by thinning from above (REDT) to obtain the expected rating. For subsequent thinnings, DMRT is computed from intensity of thinning and rating prior to thinning. Data used in regression analysis to obtain these equations came from growth plot data and actual and simulated thinnings.

A rule of thumb is available for estimating DMR so that not all trees need to be rated. For lodgepole pine and A. americanum:

$$\log DMR = -0.8814 + 0.0192\ P$$

where P is the percentage of infected trees in the stand. This equation may be used to obtain a starting value for DMR when future conditions of actual stands are to be simulated.

10. Thinning intensity in healthy stands or where thinning from below is to be done, is based on a relationship between d.b.h. and basal area:

Average stand d.b.h. after thinning (Inches)	Basal area per acre (Sq. ft.)
2.0	12.1
2.5	17.9
3.0	23.7
3.5	29.5
4.0	35.2
4.5	41.0
5.0	46.8
5.5	51.8
6.0	56.6
6.5	61.2
7.0	65.4
7.5	69.2
8.0	72.5
8.5	75.3
9.0	77.5
9.5	79.1
10.0+	80.0

These values, SQFT in subroutine LPCUT1 and LPCUT3, represent one possible series of densities that could be used to guide successive thinnings. The growing stock level shown above is 80; reserve basal area remains constant at 80 square feet after stand d.b.h. reaches 10.0 inches. Other stocking levels are named the same way. For example, level 100 means that reserve basal area will be 100 square feet when d.b.h. is 10.0 inches or larger. Basal areas for level 100 and diameters smaller than 10.0 inches are obtained by multiplying each basal area of level 80 by the amount 100/80. Values for any stocking level, THIN or DLEV in LPMIST, are computed similarly.

Equations for DBHP in subroutine LPCUT1 and LPCUT3 also describe the tabulated values. In this case, diameter is estimated when basal area and the desired stocking level are known. Variables BREAK and BUST indicate points where the relationship of diameter to basal area has been broken into segments for convenience in regression analysis.

Growing stock levels to be left after thinning from below are indicated by assigning values to THIN and DLEV on data card type 3. Each assigned value is a growing stock level or the basal area left when d.b.h. after thinning is 10.0 inches or greater.

11. Equations for DBHE (used as DBHT) in LPCUT1 and LPCUT3 and for ADDHT in the main routine were derived from data obtained in a variety of thinned stands. Thinning may be simulated on a computer. The sequence of operations is as follows:
    a. Convert a series of stand tables of actual stands to 1,000 trees each. Assign the appropriate total height to each tree.
    b. Compute average d.b.h. and average height of each stand.
    c. Create a set of 1,000 randomly arranged diameters, each with its corresponding height.
    d. Create groups of trees, based on percentages of trees to be retained (PRET), and tally the largest (thinning from below) or smallest (thinning from above) d.b.h. in each group. For example, if 25 percent of the trees are to be retained, divide the 1,000 randomly arranged diameters into 250 groups of four trees each. Tally the largest or smallest diameter in each group of four trees. Also tally the corresponding height.
    e. Repeat step d for various percentages of retention and for each stand.
    f. Compute the average d.b.h. (DBHE) and average height that results from each percentage retention (PRET) in each stand.
    g. Determine the difference between each average height and the height of the stand before thinning.
    h. Use regression analysis to obtain equations that predict diameter after thinning (DBHE) and change in height (ADDHT), from diameter before thinning (DBHO) and percentage of trees retained (PRET).
    i. Compare predicted and actual values of DBHE and ADDHT, using data from actual stands, to insure that adequate predictions can be made.
12. Values for AGEO, DBHO, and DENO on data card type 3 are obtained by examining a variety of young stands. For each site class, average d.b.h. at various ages is determined for each of several levels of stand density.

Description of Program LPMIST

Program LPMIST consists of a main program and four subroutine subprograms. The main program performs most computations and writes the yield tables. Three subroutines compute average stand d.b.h. and stand density after thinning. The fourth subroutine computes factors that are used in the main program to convert total cubic feet to other units.

Operations performed by each routine are identified by the comment statements of the source program (appendix 1). Initial stand conditions and values of several control variables are read into computer memory in the order and format given in the tabulation of order and contents of the data deck. The number of yield tables computed and printed is determined by the values assigned NTSTS on card type 1 and MIX on card type 2. NTSTS is the number of sets of tables to be produced. MIX is the number of tables in a set or the number of growing stock levels (DSTY) tested.

Operations are performed in the following sequence:

1. Compute average height, basal area, volume, and mistletoe rating just prior to initial thinning.
2. Compute the current mistletoe rating after thinning, and execute the thinning if current rating is below 3.0. If thinning is possible, subroutines compute the new stand density and average d.b.h. as explained below. The main program then computes the new average stand height.
3. Compute post-thinning volumes.
4. Compute amounts removed by thinning and data describing conditions before and after thinning.
5. Advance d.b.h., height, and mistletoe rating one prediction period, and compute new volumes. Mistletoe rating is computed as an increase from a previous value or as a projection from initial infection, depending upon whether or not the stand has been thinned since infection.
6. Print values appropriate to the stand age if thinning is not scheduled.
7. If thinning is scheduled, re-thin by return of program control to the operations described in item 2.
8. Repeat operations described in items 2 to 7, inclusive, until stand age reaches the limit set by ROTA on data card type 3. Only one thinning in diseased stands will be from above, and simulated by LPCUT2. Subsequent thinnings will increase average d.b.h. and height, but by lesser amounts than where the smaller trees make up a very large percentage of those removed. This effect has been observed in subsequent thinnings of actual stands, and is simulated by LPCUT3.

Zero punches in any data card will cause control to move to the end of the program, a diagnostic message to be printed, and termination of the job.

Clearcutting at the oldest age of interest (ROTA) is assumed, because of the serotinous nature of the cones of most lodgepole pines in Colorado and Wyoming. The program can be modified to show volume reserved for shelterwood or for seed trees, if desired.

Subroutines LPCUT1 and LPCUT3 compute average stand d.b.h. after thinnings that remove many of the smaller trees and thus produce increases in average stand diameter and height. Successive percentages of trees to be retained (PRET) are tested until the relationship between d.b.h., basal area, and number of trees is mathematically correct and d.b.h. and basal area agree with the growing stock level specified by THIN or DLEV. Two major loops are provided in the subroutines because two equations are needed for estimating post-thinning d.b.h. (DBHE).

Subroutine LPCUT2 uses thinning standards based on the goals of sanitation thinning, not on THIN or DLEV. The reduced infection rating to be attained (DMRT) is computed by the main program as a function of average stand d.b.h.:

D.b.h. (Inches)	Rating
2	0
4	0.5
6	1.0
8	1.5
10	2.0

LPCUT2 then computes the reduction in stand density (REDT) needed to attain this goal, using d.b.h. and rating just prior to thinning. D.b.h. after thinning (DBHT) can then be determined directly from the same equations as those for DBHE in LPCUT1. Successive approximations are unnecessary because percentage of trees to be retained (PRET) is known before DBHE (as DBHT) is computed.

Order and Contents of the Data Deck

Card type	Frequency read	Variable name	Columns	Format	Description of variable
1	Once	NTSTS	1-4	I4	Number of sets of yield tables to be produced. Each set is based on values of the variables on appropriate data cards of types 2 and 3.
2	Each test	JCYCL	1-4	I4	Interval between intermediate cuts. A multiple of RINT.
		MIX	5-8	I4	Number of stocking levels or values of DLEV to be examined in one test.
3	Each test	AGEO	1-8	F8.3	Initial age to be shown in a yield table. Stand age when first thinning occurs.
		DBHO	9-16	F8.3	Average stand d.b.h. just prior to initial thinning at age AGEO and with density DENO.
		DENO	17-24	F8.3	Number of trees per acre just prior to initial thinning at age AGEO.
		DSTY	25-32	F8.3	Lowest growing stock level in a test for intermediate cuts after initial thinning. Level will increase by 10 as many times as specified by MIX.
		RINT	33-40	F8.3	Number of years for which growth and infection equations make one projection of growth or change. Value is 10.0 for the equations given in Appendix 1.
		ROTA	41-48	F8.3	Final age for which stand data are to be given in a yield table.
		SITE	49-56	F8.3	Site index on which the set of yield tables is to be based.
		THIN	57-64	F8.3	Growing stock level for initial thinning at age AGEO. May equal DLEV.
		START	65-72	F8.3	Stand age at which dwarf mistletoe infection begins. Never enter zero. Enter number larger than ROTA if infection will not occur during the rotation.

Modifications for Other Species

Replacement of several statements will modify the program for other species or regions. Replacements needed are:

1. Statements for SQFT, DBHP, BREAK, BUST, and related computations that contain the ratio of DLEV or THIN to 80.0, if desired. This change is needed if standards for reserve stand in LPCUT1 and LPCUT3 will be different from those shown in the tabulation of the previous section.
2. Statements for TOTO and TOTT, to make cubic volumes per acre correct for the species and tree volume equations selected.
3. Statements for FCTR and PROD in subroutine LPVOL that are correct for the species and tree volume equations selected.
4. Statements for HTSO, ADDHT, and PCT so that height growth, changes in height due to thinning, and reductions in growth caused by dwarf mistletoe will be appropriate for the species.
5. Statements for or that include DMR, DMRT, and REDT; to show correct relationships for the host-parasite interaction being simulated.
6. Statement for DBHO, based on a growth study in healthy stands of the species of interest and a statement for TEM to compute the effect of mistletoe on diameter growth.
7. Statements for DBHE in subroutine LPCUT1 and LPCUT3 and for DBHT in LPCUT2 that apply to the species of interest.
8. Statements that describe periodic losses in numbers of trees in both healthy (OUT) and diseased (DIE) stands.
9. Table headings.

A Sample Problem

The sample problem described here provides additional description of the data deck and of the output (appendix 2). It can also serve as a test problem to check accuracy of punching of the source deck and to test compatibility with local equipment.

Assume a forest composed of even-aged stands of lodgepole pine that differ in degree of infection by dwarf mistletoe. Site indexes range from 30 to 85 (base 100 years) and infection ratings range from 0 to 6.

Problems to be solved by the manager of such a forest include:

1. What growth can be expected in healthy stands of known site quality for various combinations of thinning frequency and intensity?
2. How is this growth affected by various degrees of dwarf mistletoe infection and time of initial sanitation thinning?
3. On the basis of potential yields of each stand, is thinning, replacement, or no treatment appropriate for the stand at this time?
4. Does each treatment decision appear appropriate when impacts on other forest resources are considered?

This series of questions cannot call forth answers that contribute to good land management unless all numerical results can be estimated to a useful degree of accuracy. Program LPMIST provides such answers for the tree component of the forest.

Our hypothetical manager may decide to compare yields of healthy stands with those initially infected at age 10. Other variables would remain constant for both tests except for stand conditions at initial thinning and intensity of thinning. His data deck could contain the following values:

NTSTS	- 3, for healthy stands (test 1), diseased and thinned at age 30 (test 2), and diseased and first thinned at age 50 (test 3).
JCYCL	- 20 years.
MIX	- 3, or 3 intensities of thinning will be examined in each test. For brevity, not all tables will be reproduced in appendix 2.
AGEO	- 30.0 years for two tests and 50.0 years for the third.
DBHO	- 4.5 inches for two tests, 3.0 inches for the third.
DENO	- 1000.0 trees for two tests, 2500.0 trees for the third.
DSTY	- 80.0, lowest subsequent thinning level of the 3 to be examined.
RINT	- 10.0 years.
ROTA	- 130.0 years.
SITE	- 70.0 feet, base 100 years.
THIN	- 120.0, level for initial thinning.
START	- 200.0, 10.0, and 10.0 years on type 3 data cards of test 1, test 2, and test 3, respectively. Any number larger than the value of ROTA could replace the 200.0 shown.

These values will provide data for comparing differences in yields between healthy and diseased stands and between different types of diseased stands. Values must be read from data cards assembled in the order: (1) type 1, (2) type 2 of test 1, (3) type 3 of test 1, (4) type 2 of test 2, (5) type 3 of test 2, (6) type 2 of test 3, and (7) type 3 of test 3. Additional

tests could be made to examine the effect of variations in thinning intensity or in any other control variable.

Tables produced by LPMIST can be used in many ways to assist in decisionmaking. Yields, number of noncommercial cuts, number of scheduled cuts that cannot be made, and size of the average tree are some of the values produced. Money yields and rates earned can be computed if necessary data on costs and stumpage values are available. Stand ages at culmination of mean annual increment, and rates earned can help the manager determine suitable rotations for his working groups.

A manager examining the tables in appendix 2, for example, might reach the following conclusions:

1. A stand initially infested at age 10 and then left without treatment for 40 years, can produce only a few posts and some fuelwood by age 130 (fifth table of appendix 2). Planned frequency and intensity of thinning will have no influence because the stand is already too heavily infested by age 50 for treatment to produce improvement.
2. A stand infested by dwarf mistletoe at age 10 but thinned at 20-year intervals beginning at age 30, can produce useful wood products. Yields, including thinnings, would be less than those from healthy stands with the same site index and thinned according to the same schedule. Also, actual yields of diseased stands would be less than the computed volumes because no reduction has been made for amounts of wood lost due to pitch or distorted grain.
3. In healthy stands, largest yields would be produced with relatively light thinnings, such as to level 100. In thinned, diseased stands, largest yields would be produced with heavier thinnings, such as to level 80. Comparing the best yields in thinned stands with and without dwarf mistletoe, diseased stands produce about 70 percent of the merchantable cubic-foot and board-foot volumes of healthy stands.

Literature Cited

Alexander, Robert R.
1966. Site indexes for lodgepole pine with correction for stand density: Instructions for field use. U. S. Forest Serv. Res. Pap. RM-24, 7 p. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

Baranyay, J. A., and L. Safranyik.
1970. Effect of dwarf mistletoe on growth and mortality of lodgepole pine in Alberta. Can. Dep. Fish. and Forest. Pub. 1285, 19 p.

Hawksworth, Frank G.
1958. Survey of lodgepole pine dwarf-mistletoe on the Roosevelt, Medicine Bow, and Bighorn National Forests. U. S. Dep. Agr., Forest Serv. Rocky Mt. Forest and Range Exp. Sta., Sta. Pap. 35, 13 p. Fort Collins, Colo.

____
1961. Dwarfmistletoe of ponderosa pine in the Southwest. U. S. Dep. Agr. Tech. Bull. 1246, 112 p.

________ and T. E. Hinds.
1964. Effects of dwarfmistletoe on immature lodgepole pine stands in Colorado. J. Forest. 62: 27-32.

Myers, Clifford A.
1964a. Taper tables, bark thickness, and diameter relationships for lodgepole pines in Colorado and Wyoming. U. S. Forest Serv. Res. Note RM-31, 6 p. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

____
1964b. Volume tables and point-sampling factors for lodgepole pine in Colorado and Wyoming. U. S. Forest Serv. Res. Pap. RM-6, 16 p. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

____
1966. Yield tables for managed stands with special reference to the Black Hills. U. S. Forest Serv. Res. Pap. RM-21, 20 p. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

____
1967. Yield tables for managed stands of lodgepole pine in Colorado and Wyoming. U. S. Forest Serv. Res. Pap. RM-26, 20 p. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

____
1969. Board-foot volumes to a 6-inch top for lodgepole pine in Colorado and Wyoming. USDA Forest Serv. Res. Note RM-157, 3 p. Rocky Mt. Forest and Range Exp. Sta., Fort Collins, Colo.

Weir, J. R.
1916. Mistletoe injury to conifers in the Northwest. U. S. Dep. Agr. Bull. 360, 39 p.

APPENDIX 1

Listing of Program LPMIST

```
      PROGRAM LPMIST
     1(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C TO COMPUTE AND PRINT YIELD TABLES FOR EVEN-AGED STANDS OF LODGEPOLE
C PINE INFECTED BY OWARF MISTLETOE.
C
C DEFINITIONS OF VARIABLES.
C
C      AODHT = INCREASE OR DECREASE IN AVERAGE STAND HEIGHT BY THINNING.
C      AGEO = INITIAL AGE IN YIELD TABLE.
C      BASC = BASAL AREA CUT PER ACRE.
C      BASD = BASAL AREA PER ACRE BEFORE THINNING.
C      BAST = BASAL AREA PER ACRE AFTER THINNING.
C      BDFC = BOARD FEET CUT PER ACRE.
C      BOFO = BOARD FEET PER ACRE BEFORE THINNING.
C      BDFT = BOARO FEET PER ACRE AFTER THINNING.
C      CFMC = MERCHANTABLE CU. FT. CUT PER ACRE.
C      CFMD = MERCH. CU. FT. PER ACRE BEFORE THINNING.
C      CFMT = MERCH. CU. FT. PER ACRE AFTER THINNING.
C      OBHO = AVERAGE STAND O.B.H. BEFORE THINNING.
C      DBHT = AVERAGE STAND D.B.H. AFTER THINNING.
C      OENC = TREES CUT PER ACRE.
C      OENO = TREES PER ACRE BEFORE THINNING.
C      DENT = TREES PER ACRE AFTER THINNING.
C      OIE = TREES LOST IN DISEASED STANDS IN 10 YEARS, IN PERCENT.
C      OLEV = GROWING STOCK LEVEL FOR INTERMEDIATE CUTS AFTER THE FIRST.
C      OMR = OWARF MISTLETOE INFECTION RATING.
C      OMRT = MAXIMUM INFECTION EXPECTEO IN STANDS AFTER THINNING. GOAL
C           FOR STANDS NOT ALREAOY BEYOND OMR OF 3.0.
C      OSTY = LOWEST VALUE OF OLEV USED IN A TEST.
C      HTSO = TREE HEIGHT BEFORE THINNING.
C      HTST = TREE HEIGHT AFTER THINNING.
C      JCYCL = INTERVAL BETWEEN INTERMEOIATE CUTS.
C      KSTEP = INOICATOR WITH VALUE OF ONE IF CURRENT THINNING IS FROM
C           BELOW ANO TWO IF CURRENT THINNING IS FROM ABOVE.
C      KTR = INOICATOR WITH VALUE GREATER THAN ZERO IF A SCHEDULED
C           THINNING HAS BEEN SKIPPED BECAUSE MISTLETOE INDEX IS TOO HIGH
C           OR BECAUSE STAND IS ALREAOY TO SPECIFIEO STOCKING.
C      MIX = NUMBER OF STOCKING LEVELS EXAMINEO PER TEST.
C      NFLAG = INOICATOR WITH VALUE GREATER THAN ZERO IF A THINNING FROM
C           ABOVE HAS BEEN MADE AT ANY TIME.
C      NTSTS = NUMBER OF TESTS PER BATCH.
C      OUT = PERCENT MORTALITY IN HEALTHY STANDS.
C      PCT = PERIOOIC HEIGHT INCREASE IN INFESTEO STAND, AS A PERCENTAGE
C           OF THE INCREASE IN COMPARABLE HEALTHY STANOS.
C      PRET = PERCENTAGE OF TREES RETAINEO AFTER THINNING.
C      REOT = PERCENTAGE REDUCTION IN NUMBER OF TREES WHEN OMR IS
C           REDUCEO TO OMRT BY THINNING.
C      RINT = NUMBER OF YEARS FOR WHICH A SINGLE PROJECTION IS MADE.
C      ROTA = FINAL AGE IN YIELD TABLE.
C      SITE = SITE INOEX.
C      START = STANO AGE AT TIME OF INITIAL INFECTION.
C      TEM = PERIOOIC D.B.H. INCREASE IN INFESTEO STAND, AS A PERCENTAGE
C           OF THE INCREASE IN COMPARABLE HEALTHY STANDS.
C      THIN = GROWING STOCK LEVEL FOR INITIAL THINNING.
C      TOTC = TOTAL CUBIC FEET CUT PER ACRE.
C      TOTO = TOTAL CUBIC FEET PER ACRE BEFORE THINNING.
C      TOTT = TOTAL CUBIC FEET PER ACRE AFTER THINNING.
C
      COMMON BA,BAST,OBHO,DBHT,DENO,OMR,OMRT,FCTR,PRET,PROO,REST,VOM
      OIMENSION VAR(9),TEMH(2)
C
C READ NUMBER OF TESTS PER BATCH FROM CARO TYPE ONE.
C
      REAO (5,5) NTSTS
    5 FORMAT (I4)
      IF(NTSTS .LE. 0) GO TO 310
C
C EXECUTE PROGRAM ONCE FOR EACH SET OF INITIAL VALUES OF INTEREST.
C
      OO 300 I=1,NTSTS
C
C READ INITIAL VALUES, ONE TEST AT A TIME, FROM CARO TYPES 2 AND 3.
C
      READ (5,10) JCYCL,MIX
   10 FORMAT (2I4)
      IF(JCYCL .LE. 0 .OR. MIX .LE. 0) GO TO 310
      REAO (5,15) AGEO,DBHO,OENO,DSTY,RINT,ROTA,SITE,THIN,START
   15 FORMAT (9F8.3)
      VAR(1) = AGEO
      VAR(2) = OBHO
      VAR(3) = DENO
      VAR(4) = DSTY
      VAR(5) = RINT
      VAR(6) = ROTA
      VAR(7) = SITE
      VAR(8) = THIN
      VAR(9) = START
      DO 20 L=1,9
      IF(VAR(L) .LE. 0.0) GO TO 310
   20 CONTINUE
      OLEV = 0.0
C
C PROVIDE FOR SEVERAL GROWING STOCK LEVELS PER TEST.
C
      OO 300 M=1,MIX
      A = M
      AODHT = 0.0
      BOFO = 0.0
      BOFT = 0.0
      CFMO = 0.0
      CFMT = 0.0
      DMR = 0.0
      DMRT = 0.0
      HTCUM = 0.0
      KSTEP = 1
      KTR = 0
      NFLAG = 0
      TIME = 0.0
      DLEV = (DSTY + (A * 10.0)) - 10.0
      BASD = OEND * 0.0054542 * DBHD * DBHD
C
C COMPUTE CURRENT DWARF MISTLETOE RATING, UNTHINNEO STANDS.
C
      TIME = AGEO - START
      IF(TIME .LE. 0.0) GO TO 25
      DMR = 0.31572 + 0.08654 * TIME - 0.00016 * DEND
      IF(DMR .LT. 0.0) DMR = 0.0
      IF(OMR .GT. 6.0) DMR = 6.0
C
C OBTAIN AVERAGE HEIGHT AND VOLUMES PER ACRE.
C
   25 IF(AGEO .GT. 45.0) GO TO 30
      HTSO = 3.86111 - 0.05979 * AGEO + 0.01215 * AGED * SITE
      GO TO 35
   30 HTSO = 0.33401 - 33.2866 / AGEO + 0.92341 * ALOG10(SITE) + 6.27811
     1* ALDG10(SITE) / AGED
      HTSD = 10.0 ** HTSD
   35 PCT = 1.0 - 0.0165 * OMR * DMR
      HTSD = HTSD * PCT
C
C COMPUTE TOTAL CU. FT. AND CONVERT TO OTHER UNITS.
C
      D2H = OBHD * DBHO * HTSD
      IF(O2H .GT. 7000.0) GO TO 40
      TOTD = (0.00276 * D2H - 0.00059 * BASD - 0.00577) * DEND
      GD TO 45
   40 TOTO = (0.00248 * O2H + 1.96336) * DENO
   45 IF(DBHO .LT. 5.0) GO TO 50
      VDM = OBHO
      BA = BASO
      CALL LPVOL
      BOFO = TOTO * PROO
      CFMD = TOTO * FCTR
   50 REST = THIN
C
C ENTER LOOP FOR REMAINING COMPUTATIONS AND PRINTOUT.
C
      DO 250 K=1,100
      IF(AGEO .GE. ROTA) GO TO 90
C
C COMPUTE O.B.H. AFTER THINNING.
C
      IF(OMR .LT. 3.0) GO TO 55
      BAST = BASO
      DBHT = OBHO
      DMRT = OMR
      HTST = HTSO
      KTR = 1
      GO TO 75
   55 IF(DMR .EQ. 0.0) GO TO 63
      IF(NFLAG .GT. 0) GO TO 62
      OMRT = 0.25 * DBHO - 0.50
      IF(DMRT .LT. 0.0) DMRT = 0.0
      IF(DMRT .GE. DMR) GO TO 62
      CALL LPCUT2
      NFLAG = 1
      KSTEP = 2
      GO TO 65
   62 CALL LPCUT3
      KSTEP = 1
      DMRT = DMR + 0.0279 * PRET - 2.79
      GO TO 65
   63 DMRT = OMR
      CALL LPCUT1
      KSTEP = 1
   65 IF(BAST .LT. BASO) GO TO 70
      BAST = BASO
      DBHT = DBHO
      OMRT = OMR
      HTST = HTSO
      KTR = 1
      GO TO 75
C
C COMPUTE HEIGHT AND VOLUMES AFTER THINNING.
C
   70 GO TO (71,72), KSTEP
   71 ADDHT = 6.79950 - 3.41979 * ALOG10(PRET)
      GO TO 73
   72 AODHT = 3.76362 * ALOG10(PRET) - 7.97347
   73 HTCUM = HTCUM + ADDHT
      HTST = HTSO + ADDHT
   75 JOENT = (BAST / (0.0054542 * DBHT * DBHT)) + 0.5
      DENT = JDENT
      BAST = 0.0054542 * DBHT * DBHT * DENT
      D2H = DBHT * DBHT * HTST
      IF(D2H .GT. 7000.0) GO TO 80
      TOTT = (0.00276 * D2H - 0.00059 * BAST - 0.00577) * OENT
      GD TO 85
   80 TOTT = (0.00248 * D2H + 1.96336) * DENT
C
C CONVERT TOTAL CU. FT. TO OTHER UNITS.
C
   85 IF(DBHT .LT. 5.0) GO TO 90
      VDM = DBHT
      BA = BAST
      CALL LPVOL
      BDFT = TOTT * PROD
      CFMT = TOTT * FCTR
C
C CHANGE MOOE AND ROUNO OFF FOR PRINTING.
C
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   90 JAGEO = AGEO
      JSITE = SITE
      JDENO = OENO + 0.5
      JHTSO = HTSO + 0.5
      JTOTO = (TOTO * 0.1) + 0.5
      JTOTO = JTOTO * 10
      JBASO = BASO + 0.5
      JCFMO = (CFMO * 0.1) + 0.5
      JCFMO = JCFMO * 10
      JBDFO = (BDFO * 0.01) + 0.5
      JBDFO = JBOFO * 100
      JHTST = HTST + 0.5
      JTOTT = (TOTT * 0.1) + 0.5
      JTOTT = JTOTT * 10
      JCFMT = (CFMT * 0.1) + 0.5
      JCFMT = JCFMT * 10
      IF(JCFMT .GT. JCFMO) JCFMO = JCFMT
      JBDFT = (BOFT * 0.01) + 0.5
      JBOFT = JBDFT * 100
      IF(JBDFT .GT. J8DFO) JBDFO = JBDFT
      JBAST = BAST + 0.5
      JOENC = JOENO - JOENT
      JBASC = JBASD - JBAST
      JTOTC = JTOTO - JTOTT
      JCFMC = JCFMD - JCFMT
      IF(JCFMC .LE. O) JCFMC = 0
      JBOFC = JBOFO - JBOFT
      IF(JBOFC .LE. O) JBDFC = 0
C
C WRITE HEAOINGS FOR YIELD TABLE.
C
      IF(K .GE. 2) GO TO 120
      WRITE (6,95) JSITE,THIN,OLEV
   95 FORMAT (1H1,///,39X,53HYIELDS PER ACRE OF EVEN-AGED STANDS OF LODG
     1EPOLE PINE/1H ,57X,11HSITE INDEX ,I3/1H ,38X,29HTHINNING INTENSITY
     2- INITIAL- ,F5.0,2X,12HSUBSEQUENT- ,F5.0)
      WRITE (6,100)
  100 FORMAT (1H0,25X,38HENTIRE STAND BEFORE ANO AFTER THINNING,28X,26HP
     1ERIODIC INTERMEDIATE CUTS)
      WRITE (6,105)
  105 FORMAT (1H0,9X,5HSTAND,10X,5HBASAL,3X,7HAVERAGE,2X,7HAVERAGE,3X,5H
     1TOTAL,3X,9HMERCHANT-,3X,9HSAWTIMBER,9X,5HBASAL,4X,5HTOTAL,3X,9HMER
     2CHANT-,3X,9HSAWTIMBER)
      WRITE (6,110)
  110 FORMAT (1H ,10X,3HAGE,4X,5HTREES,3X,4HAREA,4X,6HD.B.H.,3X,6HHEIGHT
     1,2X,6HVOLUME,2X,11HABLE VOLUME,4X,6HVOLUME,3X,5HTREES,3X,4HAREA,3X
     2,6HVOLUME,2X,11HABLE VOLUME,4X,6HVOLUME)
      WRITE (6,115)
  115 FORMAT (1H ,8X,7H(YEARS),3X,3HNO.,3X,6HSQ.FT.,4X,3HIN.,6X,3HFT.,4X
     1,6HCU.FT.,5X,6HCU.FT.,6X,6HBD.FT.,4X,3HNO.,3X,6HSQ.FT.,2X,6HCU.FT.
     2,5X,6HCU.FT.,6X,6HBD.FT.)
C
C WRITE TABLE ENTRIES OF DIAMETER, VOLUMES, ETC.
C
  120 WRITE (6,125) JAGEO,JOENO,JBASO,DBHD,JHTSO,JTOTO,JCFMO,JBDFD
  125 FORMAT (1H0,9X,I4,4X,I5,2X,I4,5X,F5.1,5X,I3,4X,I5,6X,I5,6X,I6)
      IF(AGEO .GE. ROTA) GO TO 255
      WRITE (6,130) JAGEO,JDENT,JBAST,OBHT,JHTST,JTOTT,JCFMT,JBDFT,JDENC
     1,JBASC,JTOTC,JCFMC,JBOFC
  130 FORMAT (1H ,9X,I4,4X,I5,2X,I4,5X,F5.1,5X,I3,4X,I5,6X,I5,6X,I6,4X,I
     15,3X,I3,5X,I4,6X,I4,8X,I5)
C
C COMPUTE VALUES FOR EACH PERIOD. THIN AS SPECIFIED.
C
      IRINT = RINT
      IK = JCYCL / IRINT
      DO 200 L=1,IK
      AGEO = AGEO + RINT
      IF(AGEO .GT. ROTA) GO TO 255
C
C COMPUTE CURRENT OWARF MISTLETOE RATING.
C
      TIME = AGEO - START
      IF(OMR .GT. 0.0) GO TO 135
      IF(TIME .LE. 0.0) GO TO 150
      OMR = 0.31572 + 0.08654 * TIME - 0.00016 * OENT
      GO TO 145
  135 IF(OMRT .LE. 1.0) GO TO 140
      OMR = OMRT + 0.07 * RINT
      GO TO 145
  140 OMR = OMRT + (0.03 + 0.038 * OMRT) * RINT
      IF(L .LE. 2) GO TO 145
      OMR = OMR + 0.07 * RINT
  145 IF(OMR .LT. 0.0) OMR = 0.0
      IF(OMR .GT. 6.0) OMR = 6.0
C
C COMPUTE NEW O.B.H. BEFORE THINNING AND ROUNO OFF TO 0.1 INCH.
C
  150 OBHO = 1.0222*OBHT + 0.0151*SITE - 1.2417*ALOG10(BAST) + 2.1450
      IF(OMRT .LE. 3.9) GO TO 155
      TEM = (OBHO - OBHT) * (1.0 - (0.192 * DMRT - 0.754))
      O8HO = OBHT + TEM
  155 IOBHO = OBHO * 10.0 + 0.5
      OBHO = IOBHO
      O8HO = DBHO * 0.1
      IF(OENT .GT. 1000.0) GO TO 160
      OIE = (3.81 * OMRT - 6.63) * 0.01
      IF(OIE .LT. 0.0) OIE = 0.0
      GO TO 165
  160 OIE = (8.64 + 3.28 * OMRT) * 0.01
  165 OUT = 0.0
      IF(OBHT .GE. 10.0) GO TO 170
      OUT = 0.05285 - 0.01346 * OBHT + 0.00226 * OBHT * OBHT + 0.0000066
     1* BAST * BAST - 0.0001931 * OBHT * BAST
      IF(OUT .LT. 0.0) OUT = 0.0
  170 IF(OIE .LT. OUT) OIE = OUT
      JOENO = (OENT * (1.0 - OIE)) + 0.5
      OEND = JOENO
      BASD = DENO * (0.0054542 * OBHO * OBHO)
C
C OBTAIN AVERAGE HEIGHT ANO VOLUMES PER ACRE.
C
      DO 180 J=1,2
      LUB = J
      GO TO (172,174), LUB
  172 YARS = AGEO
      GO TO 176
  174 YARS = AGEO - RINT
  176 IF(YARS .GT. 45.0) GO TO 178
      TEMH(J) = 3.86111 - 0.05979 * YARS + 0.01215 * YARS * SITE
      GO TO 180
  178 TEMH(J) = 0.33401 - 33.2866 / YARS + 0.92341 * ALOG10(SITE) + 6.2
     1811 * ALOG10(SITE) / YARS
      TEMH(J) = 10.0 ** TEMH(J)
  180 CONTINUE
      PCT = 1.0 - 0.0028 * DMRT * DMRT * DMRT
      CHNG = (TEMH(1) - TEMH(2)) * PCT
      HTSD = HTST + CHNG
C
C COMPUTE TOTAL CU. FT. ANO CONVERT TO OTHER UNITS.
C
      D2H = OBHO * DBHO * HTSO
      IF(O2H .GT. 7000.0) GO TO 185
      TOTD = (0.00276 * O2H - 0.00059 * BASO - 0.00577) * OENO
      GO TO 190
  185 TOTO = (0.00248 * O2H + 1.96336) * DENO
  190 IF(DBHO .LT. 5.0) GO TO 195
      VDM = DBHO
      BA = BASO
      CALL LPVOL
      BDFO = TOTO * PROD
      CFMD = TOTO * FCTR
C
C CHANGE MOOE ANO ROUND OFF FOR PRINTING.
C
  195 IF(L .EQ. IK) GO TO 205
      KDENO = DENO + 0.5
      KAGEO = AGEO
      KHTSO = HTSD + 0.5
      KBASO = BASO + 0.5
      KTOTO = (TOTO * 0.1) + 0.5
      KTOTO = KTOTO * 10
      KCFMD = (CFMO * 0.1) + 0.5
      KCFMO = KCFMO * 10
      KBDFO = (BOFO * 0.01) + 0.5
      KBOFO = KBDFO * 100
C
C WRITE VALUES FOR THE PERIOD IF THINNING IS NOT DUE.
C

      WRITE (6,125) KAGEO,KOENO,KBASD,DBHO,KHTSO,KTOTO,KCFMD,KBOFO
      OBHT = DBHO
      BAST = BASO
      DENT = OENO
      DMRT = OMR
      HTST = HTSO
  200 CONTINUE
C
C PREPARE TO START LOOP AGAIN FOR NEXT THINNING.
C
  205 REST = OLEV
  250 CONTINUE
  255 IF(START .GE. ROTA) GO TO 265
      WRITE (6,260) START,OMR,ROTA
  260 FORMAT (1H0,25X,41HOWARF MISTLETOE INFECTION STARTEO AT AGE ,F4.
     116H ANO RATING WAS ,F5.1,8H AT AGE ,F4.0)
      GO TO 275
  265 WRITE (6,270) ROTA
  270 FORMAT (1H0,25X,63HOWARF MISTLETOE INFECTION DIO NOT OCCUR OURIN
     1THE ROTATION OF ,F4.0,7H YEARS.)
  275 IF(KTR .EQ. 0) GO TO 285
      WRITE (6,280)
  280 FORMAT (1H0,25X,52HNOTE THAT NOT ALL SCHEOULEO THINNINGS WERE PO
     1IBLE.)
  285 WRITE (6,290)
  290 FORMAT (1H0,25X,66HMERCH. CU. FT. - TREES 6.0 INCHES D.B.H. ANO
     1RGER TO 4-INCH TOP.)
      WRITE (6,295)
  295 FORMAT (1H0,25X,59HBO. FT. - TREES 6.5 INCHES O.B.H. ANO LARGER
     1 6-INCH TOP.)
C
C PREPARE FOR NEXT TABLE OF THE TEST.
C
      AGEO = VAR(1)
      OBHO = VAR(2)
      OENO = VAR(3)
  300 CONTINUE
      GO TO 350
C
C PROGRAM CONTROL GOES HERE IF ANY ZEROS IN OATA OECK.
C
  310 WRITE (6,320)
  320 FORMAT (1H1,///,10X,64HEXECUTION STOPPEO BECAUSE OF NEGATIVE OR
     1RO ITEM ON OATA CARO.)
  350 CALL EXIT
      ENO
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      SUBROUTINE LPVOL
C
C TO CONVERT TOTAL CU. FT. TO MERCH. CU. FT. AND TO BD. FT.
C
      COMMON BA,BAST,DBHO,DBHT,DEND,DMR,DMRT,FCTR,PRET,PROD,REST,VOM
      FCTR = 0.0
      PROD = 0.0
      IF(VOM .LT. 5.0) GO TO 10
C
C OBTAIN CONVERSION FACTORS FOR MERCH. CU. FT. - VOLUMES TO 4.0-INCH TOP
C IN TREES 6.0 INCHES D.B.H. AND LARGER.
C
      IF(VOM .GT. 6.7) GO TO 2
      FCTR = 0.31963 * VOM - 1.42291
      GO TO 6
    2 IF(VOM .GT. 9.8) GO TO 4
      FCTR = 3.68255 - 0.14007 * VOM - 13.54644 / VOM
      GO TO 6
    4 FCTR = 0.99503 - 0.58018 / VOM
    6 IF(VOM .LT. 8.0) GO TO 10
C
C OBTAIN CONVERSION FACTORS FOR BD. FT. - VOLUMES TO 6-INCH TOP IN TREES
C 6.5 INCHES D.B.H. AND LARGER.
C
      IF(VOM .GT. 10.0) GO TO 8
      PROD = 2.08874 + 0.18091 * VOM + 0.00045 * BA
      GO TO 10
    8 PROD = 0.16583 + 3.74174 * ALOG10(VOM)
   10 RETURN
      END

      SUBROUTINE LPCUT1
C
C TO ESTIMATE INCREASE IN AVERAGE D.B.H. DUE TO THINNING LODGEPOLE PINE
C IF DWARF MISTLETOE RATING EQUALS ZERO.
C
      COMMON BA,BAST,DBHD,DBHT,DEND,DMR,DMRT,FCTR,PRET,PROD,REST,VOM
      IF(DBHO .LT. 9.5) GO TO 30
C
C COMPUTE D.B.H. IF DBHO IS LARGE ENOUGH FOR BASAL AREA TO REMAIN CONSTANT.
C
      PRET = 100.0
      DO 21 KJ=1,100
      IF(PRET .LT. 50.0) GO TO 5
      DBHE = 0.44222 + 1.03170 * DBHD - 0.00816 * (PRET - 50.0) - 0.0000
     19 * (PRET - 50.0) * (PRET - 50.0)
      GO TO 11
    5 PDBHE = 0.37321 - 0.17274 * ALOG10(PRET) + 0.79921 * ALOG10(DBHD)
     1 + 0.09315 * ALOG10(PRET) * ALOG10(DBHO)
      DBHE = 10.0 ** PDBHE
   11 IDBHE = DBHE  * 10.0 + 0.5
      DBHE = IDBHE
      DBHE = DBHE * 0.1
      DENE = DEND * PRET * 0.01
      NDENE = DENE + 0.5
      DENE = NDENE
      BASE = 0.0054542 * DBHE * DBHE * DENE
      NBASE = BASE * 10.0 + 0.5
      BASE = NBASE
      BASE = BASE * 0.1
      TMPY = 0.0054542 * DBHE * DBHE
      TEM = BASE - REST
      IF(TEM .LE. TMPY) GO TO 70
      IF(TEM .LT. 4.0) GO TO 20
      PRET = PRET - 1.0
      GO TO 21
   20 PRET = PRET - 0.3
   21 CONTINUE
      GO TO 70
C
C COMPUTE D.B.H. IF BASAL AREA INCREASES WITH D.B.H.
C
   30 PRET = 40.0
      IF(DBHO .GT. 7.0) PRET = 70.0
      DO 65 J=1,100
      IF(PRET .GE. 50.0) GO TO 40
      PDBHE = 0.37321 - 0.17274 * ALOG10(PRET) + 0.79921 * ALOG10(DBHO)
     1 + 0.09315 * ALOG10(PRET) * ALOG10(DBHO)
      DBHE = 10.0 ** PDBHE
      GO TO 45
   40 DBHE = 0.44222 + 1.03170 * DBHD - 0.00816 * (PRET - 50.0) - 0.0000
     19 * (PRET - 50.0) * (PRET - 50.0)
   45 IDBHE = DBHE * 10.0 + 0.5
      DBHE = IDBHE
      DBHE = DBHE * 0.1
      DENE = DEND * (PRET * 0.01)
      NDENE = DENE + 0.5
      DENE = NDENE
      BASE = 0.0054542 * DBHE * DBHE * DENE
      NBASE = BASE * 10.0 + 0.5
      BASE = NBASE
      BASE = BASE * 0.1
      BREAK = 49.9 * REST / 80.0
      IF(BASE .GT. BREAK) GO TO 50
      DBHP = (80.0 / REST) * (0.08682 * BASE) + 0.94636
      GO TO 52
   50 BUST = 66.2 * (REST / 80.0)
      IF(BASE .GT. BUST) GO TO 51
      DBHP = (80.0 / REST) * (0.10938 * BASE) - 0.17858
      GO TO 52
   51 TMPY = BASE * (80.0 / REST)
      TEM = TMPY * TMPY
      DBHP = 19.04740 * TMPY - 0.26673 * TEM + 0.0012539 * TEM * TMPY
     1 - 448.76833
      IF(TMPY .GT. 80.0) DBHP = DBHO + 0.8
   52 IDBHP = DBHP * 10.0 + 0.5
      DBHP = IDBHP
      DBHP = DBHP * 0.1
      IF(DBHP - DBHE) 60,70,61
   60 PRET = PRET * 1.02
      GO TO 65
   61 PRET = PRET * 0.98
   65 CONTINUE
   70 DBHT = DBHE
C
C COMPUTE POST-THINNING BASAL AREA.
C
      IF(DBHT .GT. 5.0) GO TO 75
      SOFT = 11.58495 * DBHT - 11.09724
      GO TO 76
   75 IF(DBHT .GE. 10.0) GO TO 77
      TEM = DBHT * DBHT
      SOFT = 7.76226 * DBHT +0.85289 * TEM -0.07952 * TEM * DBHT-3.45624
   76 BAST = (REST / 80.0) * SQFT
      GO TO 80
   77 BAST = REST
   80 RETURN
      END

      SUBROUTINE LPCUT2
C
C TO ESTIMATE CHANGE IN AVERAGE D.B.H. DUE TO THINNING LODGEPOLE PINE
C IF DWARF MISTLETOE RATING DETERMINES THE STANDARDS.
C
      COMMON BA,BAST,DBHD,DBHT,DEND,DMR,DMRT,FCTR,PRET,PROD,REST,VOM
C
C COMPUTE STAND DENSITY AFTER A THINNING THAT REDUCES THE INDEX.
C
      IF(DMR .LT. 2.0) GO TO 5
      REDT = 77.5 - 8.5 * DBHD + 10.0 * DMR
      GO TO 10
    5 REDT = 15.5 - 8.5 * DBHD + 41.0 * DMR
   10 PRET = 100.0 - REDT
      DENT = DEND * (PRET * 0.01)
      IDENT = DENT + 0.5
      DENT = IDENT
C
C COMPUTE D.B.H. AFTER THINNING TO DESIRED DENSITY.
C
      IF(PRET .LT. 50.0) GO TO 15
      DBHT = 0.96559 * DBHD + 0.00668 * (PRET - 50.0) + 0.00015 * (PRET
     1 - 50.0) * (PRET - 50.0) - 0.50568
      GO TO 20
   15 DBHT = 0.33478 * ALOG10(PRET) + 1.42477 * ALOG10(DBHD) - 0.21199 *
     1ALOG10(PRET) * ALOG10(DBHD) - 0.67651
      DBHT = 10.0 ** DBHT
   20 IDBHT = DBHT * 10.0 + 0.5
      DBHT = IDBHT
      DBHT = DBHT * 0.1
      BAST = 0.0054542 * DBHT * DBHT * DENT
      RETURN
      END

      SUBROUTINE LPCUT3
C
C TO ESTIMATE INCREASE IN AVERAGE D.B.H. DUE TO THINNING FROM BELOW IF
C DWARF MISTLETOE RATING IS GREATER THAN ZERO.
C
      COMMON BA,BAST,DBHO,DBHT,DEND,DMR,DMRT,FCTR,PRET,PROD,REST,VOM
      IF(DBHO .LT. 9.5) GO TO 30
C
C COMPUTE D.B.H. IF DBHO IS LARGE ENOUGH FOR BASAL AREA TO REMAIN CONSTANT.
C
      PRET = 100.0
      DO 21 KJ=1,100
      IF(PRET .LT. 50.0) GO TO 5
      DBHE = 0.44222 + 1.03170 * DBHD - 0.00816 * (PRET - 50.0) - 0.0000
     19 * (PRET - 50.0) * (PRET - 50.0)
      GO TO 11
    5 PDBHE = 0.37321 - 0.17274 * ALOG10(PRET) + 0.79921 * ALOG10(DBHO)
     1 + 0.09315 * ALOG10(PRET) * ALOG10(DBHO)
      DBHE = 10.0 ** PDBHE
   11 TEM = DBHE - DBHD
      DBHE = DBHD + TEM * 0.5
      IDBHE = DBHE * 10.0 + 0.5
      DBHE = IDBHE
      DBHE = DBHE * 0.1
      DENE = DEND * PRET * 0.01
      NDENE = DENE + 0.5
      DENE = NDENE
      BASE = 0.0054542 * DBHE * DBHE * DENE
      NBASE = BASE * 10.0 + 0.5
      BASE = NBASE
      BASE = BASE * 0.1
      TMPY = 0.0054542 * DBHE * DBHE
      TEM = BASE - REST
      IF(TEM .LE. TMPY) GO TO 70
      IF(TEM .LT. 4.0) GO TO 20
      PRET = PRET - 1.0
      GO TO 21
   20 PRET = PRET - 0.3
   21 CONTINUE
      GO TO 70
C
C COMPUTE D.B.H. IF BASAL AREA INCREASES WITH D.B.H.
C
   30 PRET = 40.0
      IF(DBHO .GT. 7.0) PRET = 70.0
      DO 65 J=1,100
      IF(PRET .GE. 50.0) GO TO 40
      PDBHE = 0.37321 - 0.17274 * ALOG10(PRET) + 0.79921 * ALOG10(DBHO)
     1 + 0.09315 * ALOG10(PRET) * ALOG10(DBHO)
      DBHE = 10.0 ** PDBHE
      GO TO 45
   40 DBHE = 0.44222 + 1.03170 * DBHO - 0.00816 * (PRET - 50.0) - 0.0000
     19 * (PRET - 50.0) * (PRET - 50.0)
```

```
45 TEM = DBHE - DBHD
   DBHE = DBHD + TEM * 0.5
   IDBHE = DBHE * 10.0 + 0.5
   DBHE = IDBHE
   DBHE = DBHE * 0.1
   DENE = DENO * (PRET * 0.01)
   NDENE = DENE + 0.5
   DENE = NDENE
   BASE = 0.0054542 * DBHE * DBHE * DENE
   NBASE = BASE * 10.0 + 0.5
   BASE = NBASE
   BASE = BASE * 0.1
   BREAK = 49.9 * REST / 80.0
   IF(BASE .GT. BREAK) GO TO 50
   DBHP = (80.0 / REST) * (0.08682 * BASE) + 0.94636
   GO TO 52
50 BUST = 66.2 * (REST / 80.0)
   IF(BASE .GT. BUST) GO TO 51
   DBHP = (80.0 / REST) * (0.10938 * BASE) - 0.17858
   GO TO 52
51 TMPY = BASE * (80.0 / REST)
   TEM = TMPY * TMPY
   DBHP = 19.04740 * TMPY - 0.26673 * TEM + 0.0012539 * TEM * TMPY
  1 - 448.76833
   IF(TMPY .GT. 80.0) DBHP = DBHD + 0.8
52 IDBHP = DBHP * 10.0 + 0.5
   DBHP = IDBHP
   DBHP = DBHP * 0.1
   IF(DBHP - DBHE) 60,70,61
60 PRET = PRET * 1.02
   GO TO 65
61 PRET = PRET * 0.98
65 CONTINUE
70 DBHT = DBHE
C
C COMPUTE POST-THINNING BASAL AREA.
C
   IF(DBHT .GT. 5.0) GO TO 75
   SQFT = 11.58495 * DBHT - 11.09724
   GO TO 76
75 IF(DBHT .GE. 10.0) GO TO 77
   TEM = DBHT * DBHT
   SQFT = 7.76226 * DBHT +0.85289 * TEM -0.07952 * TEM * DBHT-3.45624
76 BAST = (REST / 80.0) * SQFT
   GO TO 80
77 BAST = REST
80 RETURN
   END
```

APPENDIX 2

Output of Sample Problem

YIELDS PER ACRE OF EVEN-AGED STANDS OF LODGEPOLE PINE
SITE INDEX 70
THINNING INTENSITY- INITIAL- 120. SUBSEQUENT- 80.

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	28	1470	210	0					
30	505	72	5.1	27	1010	210	0	495	38	460	0	0
40	502	102	6.1	36	1850	970	0					
50	500	130	6.9	41	2660	2000	0					
50	218	70	7.7	42	1500	1270	0	282	60	1160	730	0
60	216	91	8.8	50	2280	2070	8500					
70	214	112	9.8	56	3140	2910	12300					
70	136	80	10.4	56	2280	2140	9000	78	32	860	770	3300
80	136	98	11.5	61	3000	2830	12400					
90	136	116	12.5	65	3710	3520	15900					
90	84	80	13.2	66	2560	2440	11200	52	36	1150	1080	4700
100	84	94	14.3	70	3130	2990	14100					
110	84	109	15.4	73	3760	3600	17300					
110	56	80	16.2	73	2780	2670	13000	28	29	980	930	4300
120	56	92	17.4	76	3300	3180	15900					
130	56	105	18.5	78	3830	3690	18800					

DWARF MISTLETOE INFECTION DID NOT OCCUR DURING THE ROTATION OF 130. YEARS.

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 6.5 INCHES D.B.H. AND LARGER TO 6-INCH TOP.

YIELDS PER ACRE OF EVEN-AGED STANDS OF LODGEPOLE PINE
SITE INDEX 70
THINNING INTENSITY- INITIAL- 120. SUBSEQUENT- 100.

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	28	1470	210	0					
30	505	72	5.1	29	1010	210	0	495	38	460	0	0
40	502	102	6.1	36	1850	970	0					
50	500	130	6.9	41	2660	2000	0					
50	282	87	7.5	42	1870	1500	0	218	43	840	500	0
60	281	111	8.5	49	2740	2460	10100					
70	281	135	9.4	55	3760	3480	14500					
70	183	100	10.0	56	2810	2630	11100	98	35	950	850	3400
80	183	119	10.9	61	3640	3420	14700					
90	183	139	11.8	65	4470	4220	18700					
90	117	100	12.5	66	3200	3040	13700	66	39	1270	1180	5000
100	117	116	13.5	69	3890	3700	17100					
110	117	132	14.4	72	4580	4370	20600					
110	80	99	15.1	73	3450	3300	15800	37	33	1130	1070	4800
120	80	115	16.2	75	4090	3920	19200					
130	80	129	17.2	78	4720	4540	22600					

DWARF MISTLETOE INFECTION DID NOT OCCUR DURING THE ROTATION OF 130. YEARS.

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 6.5 INCHES D.B.H. AND LARGER TO 6-INCH TOP.

YIELDS PER ACRE OF EVEN-AGED STANDS OF LODGEPOLE PINE
SITE INDEX 70
THINNING INTENSITY- INITIAL- 120. SUBSEQUENT- 80.

ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	26	1380	0	0					
30	454	36	3.8	24	430	0	0	546	74	950	0	0
40	446	66	5.2	32	1050	250	0					
50	443	96	6.3	37	1760	1040	0					
50	261	62	6.6	38	1170	800	0	182	34	590	240	0
60	259	84	7.7	45	1880	1590	0					
70	258	107	8.7	51	2720	2460	10100					
70	175	77	9.0	51	2000	1830	7500	83	30	720	630	2600
80	172	96	10.1	56	2710	2540	10600					
90	172	116	11.1	60	3510	3310	14300					
90	113	80	11.4	61	2440	2310	10100	59	36	1070	1000	4200
100	113	96	12.5	64	3050	2890	13000					
110	111	110	13.5	67	3600	3430	15800					
110	77	80	13.8	68	2620	2500	11600	34	30	980	930	4200
120	76	92	14.9	71	3100	2960	14100					
130	73	102	16.0	73	3510	3370	16400					

DWARF MISTLETOE INFECTION STARTED AT AGE 10. AND RATING WAS 3.5 AT AGE 130.

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 6.5 INCHES D.B.H. AND LARGER TO 6-INCH TOP.

YIELDS PER ACRE OF EVEN-AGED STANDS OF LODGEPOLE PINE
SITE INDEX 70
THINNING INTENSITY- INITIAL- 120. SUBSEQUENT- 100.

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
30	1000	110	4.5	26	1380	0	0					
30	454	36	3.8	24	430	0	0	546	74	950	0	0
40	446	66	5.2	32	1050	250	0					
50	443	96	6.3	37	1760	1040	0					
50	332	77	6.5	37	1420	930	0	111	19	340	110	0
60	331	102	7.5	44	2260	1870	0					
70	329	127	8.4	50	3200	2850	11700					
70	235	95	8.6	51	2420	2180	8900	94	32	780	670	2800
80	234	115	9.5	56	3230	2990	12500					
90	227	134	10.4	60	4020	3780	16000					
90	227	134	10.4	60	4020	3780	16000	0	0	0	0	0
100	215	147	11.2	63	4630	4370	18900					
110	198	156	12.0	66	5020	4750	21100					
110	198	156	12.0	66	5020	4750	21100	0	0	0	0	0
120	177	156	12.7	67	5120	4860	22000					
130	153	148	13.3	69	4920	4750	21500					

DWARF MISTLETOE INFECTION STARTED AT AGE 10. AND RATING WAS 6.0 AT AGE 130.

NOTE THAT NOT ALL SCHEDULED THINNINGS WERE POSSIBLE.

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 6.5 INCHES D.B.H. AND LARGER TO 6-INCH TOP.

YIELDS PER ACRE OF EVEN-AGED STANDS OF LODGEPOLE PINE
SITE INDEX 70
THINNING INTENSITY- INITIAL- 120. SUBSEQUENT- 80.

	ENTIRE STAND BEFORE AND AFTER THINNING							PERIODIC INTERMEDIATE CUTS				
STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
50	2500	123	3.0	33	1830	0	0					
50	2500	123	3.0	33	1830	0	0	0	0	0	0	0
60	2007	150	3.7	39	2780	0	0					
70	1565	158	4.3	44	3360	0	0					
70	1565	158	4.3	44	3360	0	0	0	0	0	0	0
80	1185	149	4.8	47	3460	0	0					
90	870	128	5.2	50	3150	750	0					
90	870	128	5.2	50	3150	750	0	0	0	0	0	0
100	729	125	5.6	51	3170	1160	0					
110	611	120	6.0	52	3130	1550	0					
110	611	120	6.0	52	3130	1550	0	0	0	0	0	0
120	512	118	6.5	53	3150	2060	0					
130	429	115	7.0	54	3120	2390	0					

DWARF MISTLETOE INFECTION STARTED AT AGE 10. AND RATING WAS 6.0 AT AGE 130.

NOTE THAT NOT ALL SCHEDULED THINNINGS WERE POSSIBLE.

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 6.5 INCHES D.B.H. AND LARGER TO 6-INCH TOP.

YIELDS PER ACRE OF EVEN-AGED STANDS OF LODGEPOLE PINE
SITE INDEX 70
THINNING INTENSITY- INITIAL- 120. SUBSEQUENT- 100.

STAND AGE (YEARS)	TREES NO.	BASAL AREA SQ.FT.	AVERAGE D.B.H. IN.	AVERAGE HEIGHT FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.	TREES NO.	BASAL AREA SQ.FT.	TOTAL VOLUME CU.FT.	MERCHANT-ABLE VOLUME CU.FT.	SAWTIMBER VOLUME BD.FT.
ENTIRE STAND BEFORE AND AFTER THINNING								PERIODIC INTERMEDIATE CUTS				
50	2500	123	3.0	33	1830	0	0					
50	2500	123	3.0	33	1830	0	0	0	0	0	0	0
60	2007	150	3.7	39	2780	0	0					
70	1565	158	4.3	44	3360	0	0					
70	1565	158	4.3	44	3360	0	0	0	0	0	0	0
80	1185	149	4.8	47	3460	0	0					
90	870	128	5.2	50	3150	750	0					
90	870	128	5.2	50	3150	750	0	0	0	0	0	0
100	729	125	5.6	51	3170	1160	0					
110	611	120	6.0	52	3130	1550	0					
110	611	120	6.0	52	3130	1550	0	0	0	0	0	0
120	512	118	6.5	53	3150	2060	0					
130	429	115	7.0	54	3120	2390	0					

DWARF MISTLETOE INFECTION STARTED AT AGE 10. AND RATING WAS 6.0 AT AGE 130.

NOTE THAT NOT ALL SCHEDULED THINNINGS WERE POSSIBLE.

MERCH. CU. FT. - TREES 6.0 INCHES D.B.H. AND LARGER TO 4-INCH TOP.

BD. FT. - TREES 6.5 INCHES D.B.H. AND LARGER TO 6-INCH TOP.

Myers, Clifford A., Frank G. Hawksworth, and James L. Stewart. 1971. Simulating yields of managed, dwarf mistletoe-infested lodgepole pine stands. USDA Forest Serv. Res. Pap. RM-72, 15 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

Presents a procedure for computation of yield tables for diseased, managed, even-aged stands of lodgepole pine in Colorado and southern Wyoming. Stand age at time of initial infection by dwarf mistletoe may be varied as desired. Other control variables include stand age at initial thinning, stocking goals, and frequency of thinning. Stand conditions and severity of dwarf mistletoe infestation change with time and in response to intermediate cuttings.

Key Words: Stand yield tables, timber management, forest management, simulation, *Arceuthobium americanum*, *Pinus contorta*.

Myers, Clifford A., Frank G. Hawksworth, and James L. Stewart. 1971. Simulating yields of managed, dwarf mistletoe-infested lodgepole pine stands. USDA Forest Serv. Res. Pap. RM-72, 15 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado 80521.

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Key Words: Stand yield tables, timber management, forest management, simulation, *Arceuthobium americanum*, *Pinus contorta*.

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Key Words: Stand yield tables, timber management, forest management, simulation, *Arceuthobium americanum*, *Pinus contorta*.

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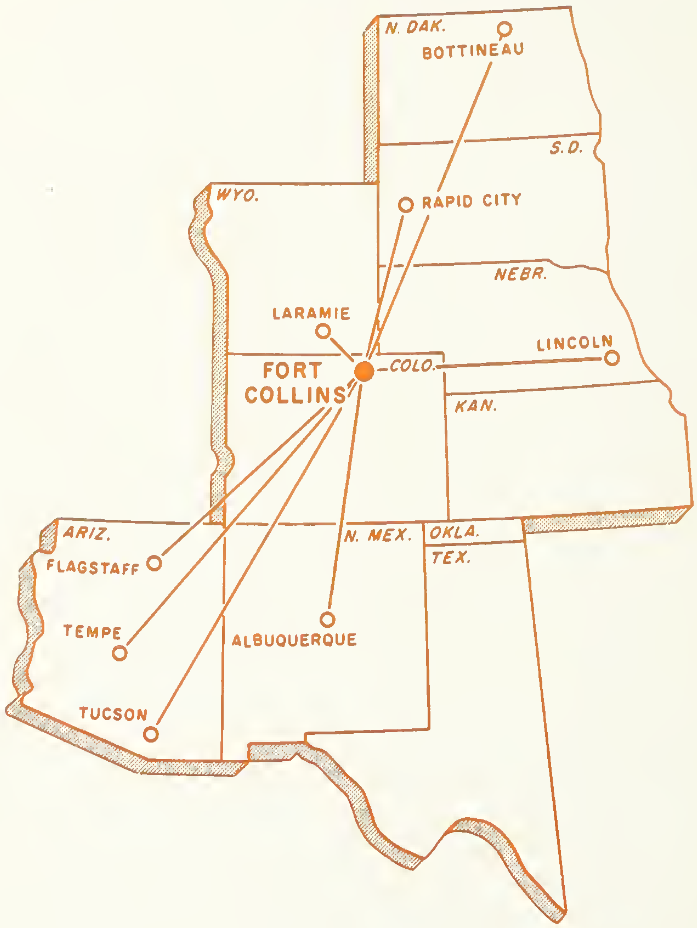
Key Words: Stand yield tables, timber management, forest management, simulation, *Arceuthobium americanum*, *Pinus contorta*.


N. DAK.
BOTTINEAU
S. D.
WYO.
RAPID CITY
NEBR.
LARAMIE
LINCOLN
FORT
COLLINS
COLO.
KAN.
ARIZ.
N. MEX.
OKLA.
TEX.
FLAGSTAFF
TEMPE
ALBUQUERQUE
TUCSON